



LAWRENCE  
LIVERMORE  
NATIONAL  
LABORATORY

# Proposal for a High Energy Nuclear Database

D. A. Brown, R. Vogt

October 13, 2005

Quark Matter 2005  
Budapest, Hungary  
August 4, 2005 through August 9, 2005

## **Disclaimer**

---

This document was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor the University of California nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or the University of California, and shall not be used for advertising or product endorsement purposes.

## Proposal for a High Energy Nuclear Database

David A. Brown<sup>1</sup> and Ramona Vogt<sup>2</sup>

<sup>1</sup> Lawrence Livermore National Laboratory, Livermore, CA, USA

<sup>2</sup> Lawrence Berkeley National Laboratory, Berkeley, CA, USA

and

Department of Physics, UC Davis, Davis, CA, USA

*Received 1 January 2005*

**Abstract.** We propose to develop a high-energy heavy-ion experimental database and make it accessible to the scientific community through an on-line interface. This database will be searchable and cross-indexed with relevant publications, including published detector descriptions. Since this database will be a community resource, it requires the high-energy nuclear physics community's financial and manpower support. This database should eventually contain all published data from Bevalac, AGS and SPS to RHIC and LHC energies, proton-proton to nucleus-nucleus collisions as well as other relevant systems, and all measured observables. Such a database would have tremendous scientific payoff as it makes systematic studies easier and allows simpler benchmarking of theoretical models to a broad range of old and new experiments. Furthermore, there is a growing need for compilations of high-energy nuclear data for applications including stockpile stewardship, technology development for inertial confinement fusion and target and source development for upcoming facilities such as the Next Linear Collider. To enhance the utility of this database, we propose periodically performing evaluations of the data and summarizing the results in topical reviews.

*Keywords:* RHIC, heavy-ion physics, database

*PACS:* 89.20.Ff, 89.20.Hh, 25.75.-q

### 1. Background and Potential Impact

We propose to create and maintain a high-energy nuclear database. This central database will be web-accessible and searchable. As with Evaluated Nuclear Data File (ENDF/B) and EXchange FORmat (EXFOR) databases [1] and HEPDATA website [2], we will store cross sections, particle yields, and single particle spectra.

We will also store data specific to higher energy reactions such as multi-particle spectra, flow and correlation observables. Thus we seek to archive whatever is needed to characterize a high-energy heavy-ion reaction. Initially we will focus on published measurements but eventually we will cross-link the data with experiment descriptions. We also envision evaluating high-energy nuclear data and reporting these results in periodic topical reviews of subsets of the data. The idea of publishing the topical reviews has already sparked the interest of a few review journals.

The utility of such a database is clear: it would organize existing data, allowing easier cross-experiment comparisons, theory benchmarking and development of systematics. In addition to the basic science needs, there is a growing list of applications for high energy nuclear data including: understanding backgrounds in proton radiography; heavy-ion driven inertial confinement fusion;  $\nu$  and  $\mu$  secondary beam source development for MINOS and the Next Linear Collider; and cosmic ray dose rates for space exploration. Most applications do not use the data directly. Instead, evaluated representations of the data are accessed by application codes.

Surprisingly, there is no national or international effort to collect and maintain such a database. The US Nuclear Data Program (USNDP) [1] has compiled low-energy nuclear reaction data for decades in the ENDF/B and other databases. Similarly, the high-energy particle physics community is served by the HEPDATA, Particle Data Group (PDG), arXiv.org and SLAC-SPIRES websites. The high-energy nuclear physics community is only partially served by these data sources. One could argue that most experiments make their published data available: for example, PHENIX posts tables of published data on the collaboration website. Inevitably this leads to a proliferation of data formats and web sites. Furthermore, experiments end and their web servers may no longer be maintained. Thus, there is a very real risk that the data could be lost. Given the volumes of data generated by experiments at the RHIC and future experiments at the LHC, GSI and elsewhere, this oversight should be rectified.

In the next few sections, we explain that the proposed database should be a community effort, motivate the need for data evaluation and topical reviews and provide some technical details. We conclude with a status of the database proposal.

## 2. Database Management Philosophy

Since this database would be a community resource, we propose a community driven management model such as the arXiv.org preprint server: the “consumers” of arXiv.org are also its “suppliers.” Physicists submit their preprints to arXiv.org because it serves as a form of advertising. They browse arXiv.org because they know others are submitting their latest results there. In this way, data collection is farmed out to the data producers – a tactic we wish to employ.

The proposed database would differ from arXiv.org in two key respects. First, the proposed database would not only contain published data but also auxiliary or supporting data sets that may be too large for publications such as Physical Review

Letters. Second, in order to assure that we only have high-quality data, we would like to piggyback on various journals' peer-review processes. Ideally this means that authors will submit both the published and auxiliary supporting data to the database when submitting papers for publication. One submission model would be to add links directly to journal submission pages. Preliminary discussions with journal editors indicate the willingness of the journals to cooperate in this endeavor.

For the experimental collaborations to have the political will to support this project, they must be given both a financial stake in the eventual product and have a hand in steering the database development. To encourage this, we propose holding annual workshops to guide development as well as discuss the topical reviews and propose new subjects for review.

### 3. Evaluations and Topical Reviews

Evaluated data provides our “best guess” representation of a particular observable. Whether one obtains this evaluation through a model calculation, systematics or a fit to raw experimental data, the final product needs to be checked against existing data and peer reviewed. However the evaluation is produced, we need a better understanding of the raw experimental data. For example, while charm production is a hot new topic in heavy ion physics, charm hadrons, particularly  $D$  mesons, have been measured in a number of experiments over a wide energy range. The extrapolation of these measurements to the total charm cross section vary considerably, even at the same energy, presumably since many of these measurements were taken before next-to-leading order perturbative QCD calculations became available. The measurements were also hampered by small statistical samples. To determine the consistency of these data with new measurements at heavy-ion colliders, these data must be re-evaluated with all previous assumptions re-examined. A topical review would provide a clear and systematic examination of all data and clarify the situation considerably.

### 4. Technical Details

Many of the tools needed for this database are available “off-the-shelf.” We envision that users will access the database through a set of JSP or PHP dynamic web pages. Both JSP and PHP have tools that simplify on-line database queries. The data itself will be a MySQL relation database. We also envision that the dynamic web pages will be able to send the data directly to a plotting utility such as LLNL's LLNLPlot Java applet. LLNLPlot can plot 2D and 3D data and is the plotting back-end of the Nuclear and Atomic Data System (NADS) [6].

A central, yet often neglected, aspect of data archives is the technical details of the data storage format. The nuclear data community traditionally suffers from a multitude of relatively obscure data formats. For example, the format still used in the ENDF/B database was designed specifically to accommodate the limitations

of now-obsolete punch cards. In some cases, the task of writing translation and visualization tools for these data sets requires a large, dedicated effort.

Given the importance of using a transparent and well-supported format, we have decided on XML (eXtensible Markup Language) as our data storage format. Documents stored in XML can be self-describing so that, with minimal effort, scientists/users 30 years from now can interpret the documents' contents. Furthermore, XML documents are represented by computationally convenient tree structures rather than the simple strings typically used to store nuclear data. XML is a mature technology with the support of thousands of programmers and web developers and is extensively supported by most common programming languages. Lastly, the many tools needed for web-based access and manipulation of XML databases have reached a state of maturity.

## 5. Current Status

We have submitted a white paper describing our proposal to the DOE-OS Heavy-Ion and Nuclear Theory programs and are circulating it in the STAR and PHENIX collaborations. Copies of the whitepaper are available upon request from the authors. Due to the budget cuts in FY05-06, it is unlikely to be funded before FY07. Despite the funding uncertainties plaguing the field, elements of this proposed project are in the process of being developed for other uses, namely the XML data format and the LLNLPlot plotting tool. Since we want this database to be a community resource, we strongly encourage members of the heavy-ion community to contact us with their questions, comments, wishes and ideas.

## Acknowledgments

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contract W-7405-Eng-48. R.V. was supported in part by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Nuclear Physics Division of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

## References

1. National Nuclear Data Center website <http://www.nndc.bnl.gov/index.jsp>.
2. HEPDATA website <http://durpdg.dur.ac.uk/HEPDATA/>.
3. Particle Data Group website <http://pdg.lbl.gov/>.
4. SLAC-SPIRES website <http://www.slac.stanford.edu/spires/>.
5. arXiv.org preprint server <http://arXiv.org/>.
6. Nuclear and Atomic Database System  
<http://nuclear.llnl.gov/CNP/nads/NADSApplet.html>.